

# Diet Preference and Meal Patterns of Weanling Pigs Offered Diets Containing Either Spray-Dried Porcine Plasma or Dried Skim Milk<sup>1,2</sup>

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**ABSTRACT:** Preference tests and meal pattern analyses were conducted to examine the feed intake response of weanling pigs to spray-dried porcine plasma (SDPP). In Exp. 1, 36 weanling pigs (mean  $\pm$  SD;  $6.2 \pm .8$  kg and 26 d of age) were allowed to choose between a SDPP diet (8.5% SDPP, 20% dried whey, 10% lactose, and .13% DL-methionine) and a dried skim milk (DSM) diet (20% each of DSM and dried whey) throughout 21 d postweaning. Twenty-eight pigs preferred the SDPP diet and seven pigs preferred the DSM diet. Preference for SDPP became apparent by d 2 (60% of total feed consumption) and increased ( $P < .01$ ) to d 21 (71% of total feed consumption). Average daily feed consumption was 371 and 172 g for the SDPP and DSM diets, respectively ( $P < .01$ ). The meal patterns of 16 weanling pigs (mean  $\pm$  SD;  $7.2 \pm .3$  kg and 26 d of age) offered either the SDPP or the

DSM diet were examined in Exp. 2. On d 3, 7, and 14 postweaning, feeding behavior was observed continuously for 18 h (0600 to 2400). Time spent consuming feed and time between periods of feeding were recorded. Although the difference was not significant, pigs fed the SDPP diet consumed 27 and 6% ( $P = .38$ ) more feed than pigs fed the DSM diet during the first 7 d and during the entire 21-d period, respectively. This difference was reflected in increased ( $P < .05$ ) rate of feed consumption on d 3 and 7. Diet had no effect ( $P > .10$ ) on meal size, the number of meals, or the percentage of time spent consuming feed. Weanling pigs prefer diets containing SDPP to those containing DSM, and the increased consumption of diets containing SDPP may be due to greater palatability.

Key Words: Animal Protein, Pigs, Feeding Preferences, Meal Patterns, Palatability

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## Introduction

Spray-dried porcine plasma (SDPP) is commonly included in weanling pig diets. During the first 2 wk postweaning, weanling pigs consume 50% more of a diet containing SDPP than of one containing dried skim milk (DSM). After the first 2 wk, consumption of a DSM diet increases to equal that of a SDPP diet (Gatnau and Zimmerman, 1990, 1991).

A possible explanation for increased consumption of diets containing SDPP is that they are more palatable than those containing milk products. Alternatively, SDPP may be a novelty that begins to wane after the first 2 wk postweaning.

Feed intake is the product of the number and size of meals consumed (meal patterns). Diet palatability is among the factors known to affect meal patterns. Increasing palatability increases both rate of feed consumption and meal size in rats (Berridge et al., 1981; Le Magnen, 1985).

The present research consisted of two experiments. In the first experiment, pigs were offered the choice between a SDPP and a DSM diet to evaluate why consumption of a SDPP diet is greater when it is the only diet provided. Preference for diets containing SDPP would be indicative of greater palatability. The objective of the second experiment was to examine meal patterns and performance responses of weanling pigs offered either a SDPP or a DSM diet.

## Materials and Methods

### Experiment 1

Thirty-six crossbred weanling pigs were used in two trials to determine the relative consumption of diets containing either SDPP or DSM. The experiment was begun at weaning and was continued for 21 d. Pigs

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were a four-way cross of Large White, Landrace, Hampshire, and Duroc ancestry and were penned individually.

Pigs were housed in a room with 18 pens. Pens with coated-wire floors measured .9 m × 2.1 m and contained two identical feeders. Feeders were equidistant from one nipple waterer and the position of the feeders within the pen was alternated daily. There were two feeder types: 1) trough feeders with a single 306-cm<sup>2</sup> opening and 2) three-opening, gravity-flow feeders with 673 cm<sup>2</sup> of opening. Nine pens contained trough feeders and nine pens contained gravity-flow feeders. Room temperature was maintained at 29°C for the 1st wk and was reduced to 27°C for the 2nd and 3rd wk of the experiment. There was continuous fluorescent lighting.

Eighteen pigs were used in each of two trials in a completely randomized design. In the first trial, equal numbers of barrows and gilts (mean ± SD; 6.8 ± .6 kg and 26 d of age) were used. In the second trial, all pigs were barrows (mean ± SD; 5.6 ± .5 kg and 26 d of age). Data from one pig in the second trial were excluded because the pig did not eat.

Pigs were allowed ad libitum access to both a DSM and a SDPP diet, both of which were fed in meal form (Table 1). Diets were formulated to contain identical amounts of lactose and to contain all other nutrients at concentrations equal to, or in excess of, the NRC (1988) requirements. Feed disappearance was determined daily. No determination of feed wastage was possible, but attempts to minimize wastage were made.

Samples of both diets were ground through a 1-mm screen before analysis. Diets were analyzed for CP, Ca, and P according to AOAC (1990) procedures. For amino acid analysis, diet samples were hydrolyzed for 20 h (6 N HCl at 107°C) before separation of amino acids by ion-exchange HPLC. After elution, amino acids were quantified fluorometrically using o-phthaldehyde as a derivatization reagent.

Preference was identified when the intake of one diet was greater than that of the other. Differences in diet consumption were determined using Wilcoxon's signed-rank test (Steel and Torrie, 1980) for paired treatments and repeated measures analysis of variance (GLM procedures of SAS, 1985). Repeated measures analysis was conducted with the trial, feeder, and trial × feeder interaction as between-pigs effects and day and diet as within-pig effects. Average daily gain and gain:feed were analyzed with a model that contained trial, feeder, and the trial × feeder interaction. Variances for feed intake and weight gain from both trials were confirmed ( $P < .05$ ) to be homogeneous (Steele and Torrie, 1980). In all analyses, pig was the experimental unit.

## Experiment 2

Sixteen crossbred weanling pigs (mean ± SD; 7.2 ± .3 kg and 26 d of age) were allotted in a randomized

Table 1. Composition of diets used in Exp. 1 and 2 (as-fed)

Item	Treatment <sup>a</sup>	
	SDPP	DSM
Ingredient, %		
Corn	38.32	38.55
Soybean meal (44% CP)	16.90	16.40
Spray-dried porcine plasma <sup>b</sup>	8.50	—
Dried skim milk	—	20.00
Dried whey	20.00	20.00
Lactose	10.00	—
Soybean oil	3.00	3.00
Dicalcium phosphate	1.60	.50
Vitamin mix <sup>c</sup>	1.00	1.00
Salt	.25	.25
DL-Methionine <sup>d</sup>	.13	—
Trace mineral mix <sup>e</sup>	.10	.10
Copper sulfate	.10	.10
Aureomycin 50	.10	.10
Nutrient composition <sup>f,g</sup>		
ME, kcal/kg <sup>h</sup>	3,510	3,660
CP, %	19.24	19.38
Lysine, %	1.28	1.30
Methionine, %	.33	.33
Ca, %	.76	.76
P, %	.64	.61
Na, % <sup>h</sup>	.79	.48

<sup>a</sup>SDPP = spray-dried porcine plasma, DSM = dried skim milk.

<sup>b</sup>Spray-dried porcine plasma (AP620) donated by American Proteine Corporation, Ames, IA.

<sup>c</sup>Provided the following amounts of vitamins per kilogram of complete diet: retinyl palmitate, 4,400 IU; cholecalciferol, 551 IU;  $\alpha$ -tocopheryl acetate, 22 IU; menadione sodium bisulfite, 3.3 mg; riboflavin, 5.5 mg; d-pantothenic acid, 22 mg; niacin, 33 mg; choline chloride, 110 mg; vitamin B<sub>12</sub>, 22  $\mu$ g; and ethoxyquin, 1.0 mg.

<sup>d</sup>DL-Methionine, 99% purity.

<sup>e</sup>Provided the following amounts of trace elements in milligrams per kilograms of complete diet: Zn (as ZnSO<sub>4</sub>·7H<sub>2</sub>O), 110; Fe (as FeSO<sub>4</sub>·H<sub>2</sub>O), 110; Mn (as MnO), 22; Cu (as CuO), 11; I (as KI), 1.1; and Se (as Na<sub>2</sub>SeO<sub>3</sub>), .3.

<sup>f</sup>As-fed basis.

<sup>g</sup>Analyzed composition.

<sup>h</sup>Calculated.

complete block design (blocks were based on pen location and litter of origin) to either a SDPP or a DSM diet (Table 1). Both diets were represented in four pairs of adjacent pens. Two trials of eight pigs each were replicated over time. Pigs were penned individually and managed similarly to those in Exp. 1. Only trough feeders were used. There was continuous fluorescent lighting.

On d 3, 7, and 14, feeding behavior was observed continuously by one person for 18 h (0600 to 2400). The time spent consuming feed and the time between feedings were recorded. After 10 min of no feeding, feeders were weighed. Pigs were considered to be feeding when observed with their heads in the feeder and masticating.

Periods of feeding were characterized into meals according to the duration of the interval(s) separating them. Periods of feeding are randomly distributed in

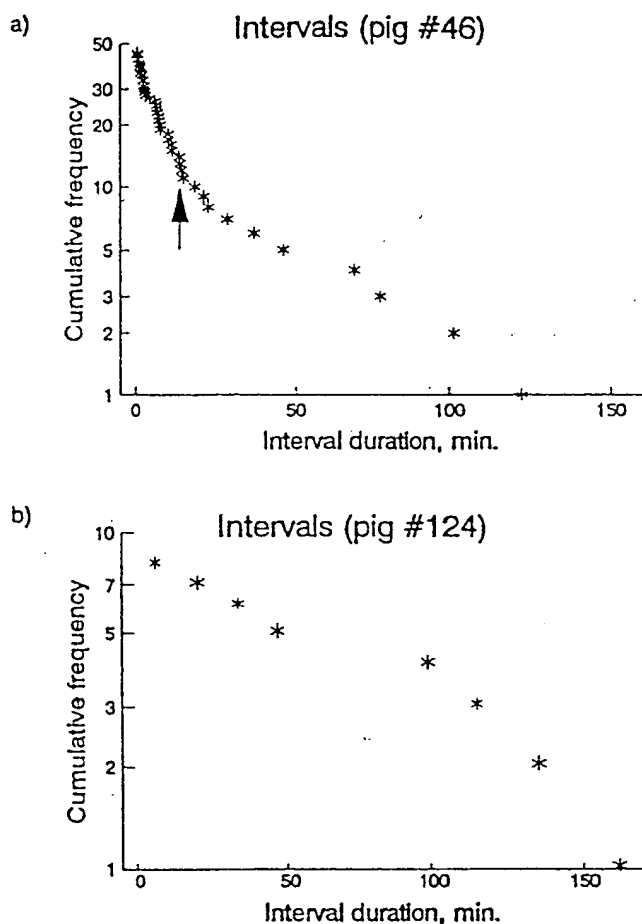


Figure 1. Representative examples of log survivorship analysis from two different pigs with different meal patterns. Intervals between periods of feeding are plotted against a cumulative log scale from longest to shortest in duration (right to left). The maximum duration of the within-meal interval is denoted with an arrow in 1a. In 1b, all intervals were considered to be separate meals.

time, and intervals separating them are of various durations. When the cumulative frequency of intervals is plotted against the interval duration, the resulting negative exponential distribution is described as a log survivorship function (Slater and Lester, 1982). In classifying periods of feeding, numerous intervals of short duration occur that represent drinking or other activities associated with the meal. These intervals are represented by the steep left portion of the distribution. Longer, and less frequent, intervals represent activities such as sleeping. These are represented by the flat right portion of the distribution. Because the probability of another interval occurring decreases as interval duration increases, the point of greatest change in slope was designated as the maximum duration of a within-meal interval (Figure 1a). All intervals greater in duration were

designated as those separating meals. In several cases, only one slope was present. In these cases, all periods of feeding were considered to be meals (Figure 1b). During the 18-h observation period, all feed consumed within a specific meal interval was considered a meal (meal size). Likewise, the number of within-meal intervals that occurred during the 18-h period was used to estimate the number of meals.

Data were analyzed using the GLM procedures of SAS (1985). The number of meals, size of meals, rate of feed consumption, and the percentage of time spent consuming feed were analyzed with diet, block (litter-mate pairs), and day (18-h observation period on d 3, 7, and 14) as main effects. Average daily gain and gain:feed were analyzed with diet and block as main effects. Daily feed consumption was analyzed using repeated measures analysis of variance with block and diet as between-pigs effects and day as the within-pig effect. The diet  $\times$  block interaction for ADG, gain:feed, or daily feed consumption could not be tested because of insufficient df. Variances for feed intake and weight gain from both trials were confirmed ( $P < .05$ ) to be homogeneous (Steele and Torrie, 1980). In all analyses, pig was the experimental unit.

## Results

### Experiment 1

No effect of trial, feeder type, or trial  $\times$  feeder type interaction was detected ( $P > .10$ ) for gain:feed. There were also no trial effects ( $P > .10$ ) for diet preference or ADG. However, there was a feeder effect ( $P < .10$ ) and a trial  $\times$  feeder type interaction ( $P < .05$ ) for diet preference. Preference for the SDPP diet was greatest for pigs fed from the trough feeders. The effect of feeder type on preference was most apparent in the first trial, in which there was little difference in consumption of either diet by pigs fed from the gravity-flow feeders. A trial  $\times$  feeder type interaction ( $P < .01$ ) also existed for ADG. Pigs consuming feed from gravity-flow feeders gained more weight in the first trial. However, ADG exhibited by pigs eating from the gravity-flow feeders in the second trial was lower than that of pigs consuming feed from trough feeders.

Intakes of the two diets throughout the 21-d experiment are depicted in Figure 2. Results of both Wilcoxon's signed-rank test ( $P < .0001$ ) and repeated measures analysis of variance ( $P < .01$ ) indicated that pigs preferred diets containing SDPP to those containing DSM. The preference for the SDPP diet increased ( $P < .01$ ; diet  $\times$  day interaction) from 60% of total feed consumption on d 2 to 71% of total feed consumption on d 21. For both trials, ADG and gain:feed (mean  $\pm$  SE) were  $352 \pm 15$  g and  $.600 \pm .111$ , respectively, during the 21-d experiment.

Table 2. Meal patterns of weanling pigs fed diets containing either SDPP or DSM (Exp. 2)<sup>a</sup>

Criterion	Diet <sup>d</sup>	Day <sup>bc</sup>			SEM <sup>d</sup>	P-value		
		3	7	14		Diet	Day	Diet × day
No. of meals	SDPP	16.24	17.00	16.63	.91	.23	.83	.66
	DSM	15.36	14.00	16.00				
Size of meals, g	SDPP	35.26	36.15	40.97	1.97	.14	.002	.05
	DSM	23.42	29.91	45.90				
Rate of consumption, g/min	SDPP	.46	.50	.56	.03	.03	.01	.32
	DSM	.32	.35	.56				
Percentage of time consuming feed, %	SDPP	14.90	11.17	10.52	.87	.60	.15	.20
	DSM	12.24	8.86	12.80				

<sup>a</sup>SDPP = spray-dried porcine plasma, DSM = dried skim milk.

<sup>b</sup>Least squares means.

<sup>c</sup>Values are for an 18-h period (0600 to 2400) on the day indicated.

<sup>d</sup>n = 23 for SDPP and n = 23 for DSM.

### Experiment 2

One pig fed the DSM diet and one pig fed the SDPP diet did not consume feed by d 3. These pigs were in different blocks and both did consume feed by d 5. Pigs fed the SDPP diet consumed 27 and 6% more feed than those fed DSM during the first 7 d and during the entire 21-d period, respectively (Figure 3). However, the difference was not significant ( $P = .38$ ).

A total of 724 meals were consumed during the intensive measurement periods. Because the maximum duration of a within-meal interval was unknown at the time of observation, feeder weights could not be obtained to coincide with all meals, resulting in the loss of data. Six hundred six meals were used to determine differences in meal size. These accounted for 89% of feed intake.

Increased consumption of the SDPP diet was reflected by an increased ( $P = .03$ ) rate of feed consumption on d 3 and 7 during the intensive measurements (Table 2). There was no overall effect of treatment ( $P > .10$ ) on the number of meals, the size of meals, or the percentage of time spent consuming feed (Table 2). However, there was a diet × day interaction ( $P = .05$ ) for meal size. Pigs fed the SDPP diet consumed larger meals than pigs fed the DSM diet on d 3 and 7, whereas pigs fed the DSM diet consumed larger meals than pigs fed the SDPP diet on d 14.

There was no difference ( $P > .10$ ) between treatments in ADG throughout the experiment (Table 3). However, there was a trend toward higher gain:feed for pigs fed the DSM diet ( $P = .06$ ) over the 21-d experiment.

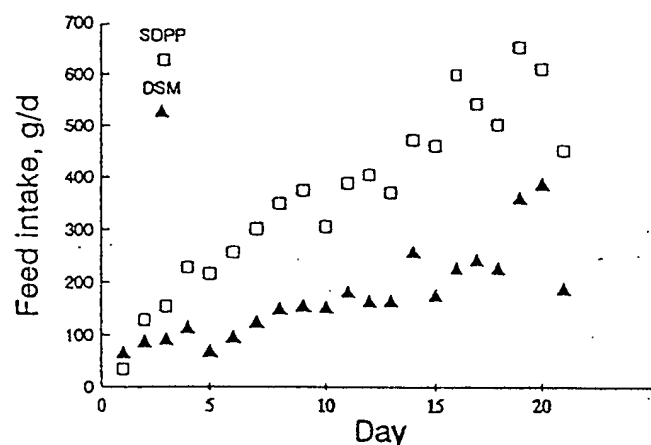


Figure 2. Intakes by weanling pigs (n = 35) of a diet containing spray-dried porcine plasma (SDPP) and one containing dried skim milk (DSM). Preference was determined from weaning (d 0) to 21 d. Diet effect,  $P < .01$ ; diet × day interaction,  $P < .01$ ; SEM = 60.

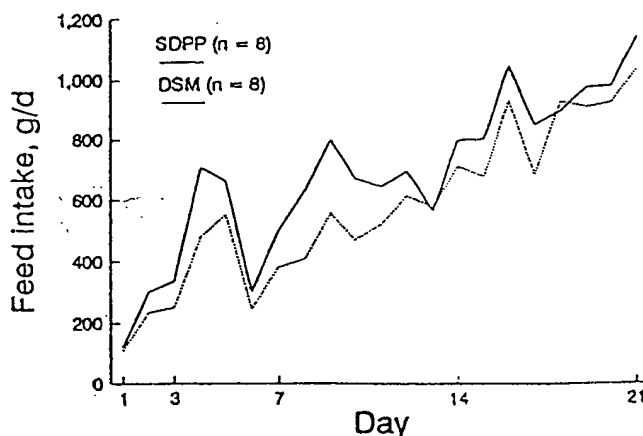


Figure 3. Intakes of diets containing either spray-dried porcine plasma (SDPP; n = 8) or dried skim milk (DSM; n = 8) throughout 21 d postweaning. Diet effect,  $P = .38$ ; block effect,  $P < .01$ ; SEM = 52.

Table 3. Performance data (Exp. 2)

Criterion and days	Diet <sup>abc</sup>		SEM <sup>c</sup>	P-value	
	SDPP	DSM		Diet	Block
ADG, g					
1-7	98	59	37	.48	.0001
1-21	401	401	20	.99	.03
Gain:feed					
1-7	.38	.35	.08	.77	.0001
1-21	.61	.66	.01	.06	.59

<sup>a</sup>Least squares means.<sup>b</sup>SDPP = spray-dried porcine plasma, DSM = dried skim milk.<sup>c</sup>n = 8 for SDPP and n = 8 for DSM.

## Discussion

### Experiment 1

Pigs were penned individually to prevent any confounding of social rank and preference (Hsia and Wood-Gush, 1983a). If penned in groups, pigs of low social rank may have been forced to consume the less-preferred diet.

Twenty-eight of 35 pigs preferred the SDPP diet. Among pigs, the range of diet preference was from complete preference for the SDPP diet to nearly complete preference for the DSM diet (Figure 4). Diet preference was influenced by feeder type. Pigs fed from the trough feeders exhibited the strongest preference for the SDPP diet (Figure 4). It is possible that bridging of the SDPP diet in the gravity-flow feeders occurred and feed intake was restricted.

Heterogeneity in diet preference has been observed by others. Even within a litter of pigs, Kare et al. (1965) found that not all pigs preferred a saccharin solution to water. Variation in diet preference may result from the method of testing used. Variation has been reported to be greater when pigs are offered continuous access to two different diets than when the presentation of the two diets is alternated (Wahlstrom et al., 1974).

Preference is not an all-or-none response; some quantity of the less-preferred diet is usually consumed. In other preference tests, investigators have observed that pigs consumed some quantity of the less-preferred diet (Wahlstrom et al., 1974; Leibbrandt et al., 1975).

Although the same amount of salt was added to each diet, the sodium content of the SDPP diet was higher than that of the DSM diet (.79 vs .48%). Baldwin (1976) observed that pigs do not prefer solutions containing salt. Although salt and sodium may not have identical influences on diet palatability, it is unlikely that preference for the SDPP diet was because of the higher sodium content.

Preference for the SDPP diet increased from d 2 to 21 postweaning. This preference indicates that palatability rather than novelty was the cause of the preference. If novelty was responsible for the effects

we observed, preference would have been expected to decrease with time.

Weanling pigs preferred diets containing SDPP. When diets containing either SDPP or DSM were offered individually, pigs consumed more of the SDPP diet (Gatnau and Zimmerman, 1990, 1991). McLaughlin et al. (1983) observed an increase in feed intake when pigs were offered diets that contained a commercial flavor. Flavored diets were also preferred to unflavored diets. Diets that contain sugars also are preferred by weanling pigs. However, when pigs are offered either a diet with or without sugar, there is no difference in overall energy intake (Wahlstrom et al., 1974). Thus, preference for a particular diet does not always indicate that pigs will consume more feed when the preferred diet is offered alone.

### Experiment 2

Others (Gatnau and Zimmerman, 1990, 1991) have observed increased intake of a SDPP diet during the

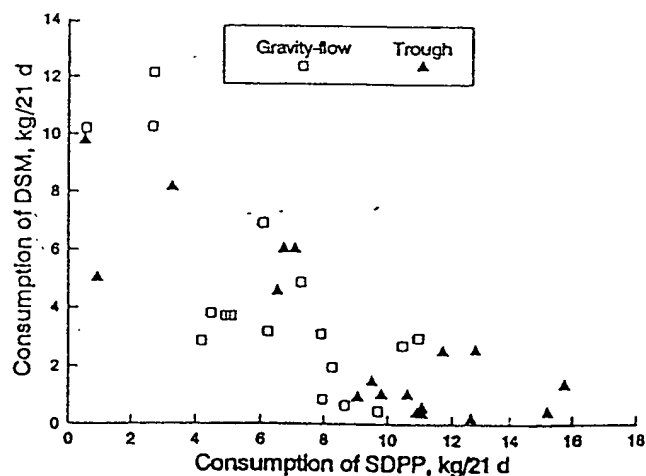


Figure 4. Relative consumption from gravity-flow or trough feeders of either a spray-dried porcine plasma (SDPP) or a dried skim milk (DSM) diet throughout 21 d postweaning. Each plotted point represents the intake of both diets.

1st wk postweaning, followed by similar intakes of SDPP and DSM diets. These authors also noted a decrease in gain:feed that was associated with increased feed intake. In the present experiment, no difference was noted in gain:feed during the 1st wk, whereas pigs fed the DSM diet tended to have higher gain:feed than pigs fed the SDPP diet throughout the 21-d experiment.

Meal patterns have been found to affect feed efficiency when diets containing crystalline amino acids are fed (Batterham and Bayley, 1989). However, for diets without crystalline amino acids, there is little evidence that meal patterns affect performance when similar amounts of feed are consumed (Liptrap and Hogberg, 1991).

The results from log survivorship analysis indicate that the maximum duration of a within-meal interval ranged from 1.3 to 31 min. This range is similar to that observed by Hsia and Wood-Gush (1983b; 8.2 to 46.8 min). Likewise, the number of meals observed in this study, when extrapolated to a 24-h basis (21 meals/24 h), is similar to that observed by others in 20-kg pigs under a 24-h light regimen (23 meals/24 h; Hsia and Wood-Gush, 1983b). In nursing pigs, Barczewski and Hartsock (1986) observed 27 sucklings/24 h.

Both proximity of other pigs and social status have been shown to affect meal patterns. Hsia and Wood-Gush (1983b) observed that the frequency of simultaneous meals was twice as high for pigs housed in the same room as for pigs housed in different rooms. The effect of social status on feeding behavior is less clear. Hsia and Wood-Gush (1983a) observed that dominant pigs consumed twice as much feed as less-dominant pigs after a period of isolation followed by introduction of a pig into an adjoining pen. In contrast, Feddes et al. (1989) found that the proportion of time that any two of three pigs in the same pen ate simultaneously was only 28% of the total time the feeder was used.

In this experiment, block (littermate pair) influenced the size of meals, the number of meals, rate of consumption, total feed intake, and ADG ( $P < .05$ ). These responses were probably due, in part, to the failure of two pigs to consume feed by d 3. Proximity of other pigs, ancestry, and previously established meal patterns (suckling patterns) may have also influenced meal patterns because littermates were often observed to be eating simultaneously.

Diet palatability affects both the rate of feed consumption and meal size. Rate of feed consumption and meal size are reduced in rats by a learned taste aversion (Berridge et al., 1981). Conversely, increased palatability through the use of flavors causes increased meal size in rats (Gentile, 1970; Le Magnen, 1985).

The short-term (approximately 1 wk) increase in feed intake observed in pigs that consumed the SDPP diet was the result both of increased rate of feed consumption and of meal size. By d 14, increased

consumption of the DSM diet was associated with increased meal size. This response may have been an attempt to compensate for lower feed intake during the first 2 wk.

Bigelow and Houpt (1988) reported meal sizes twice as large as those reported herein (70 g for 10- to 20-kg pigs). There could be several reasons for this discrepancy. First, fewer meals were observed in that experiment (13.5 meals/24 h) than in the present experiment. Also, meals that were less than 10% of the size of the average were discarded in that study. Both the rate of consumption and percentage of time spent consuming feed were similar to those reported by Bigelow and Houpt (1988).

No correlation between meal size and either the duration of the interval before ( $r = .05$ ) or after ( $r = .21$ ) the meal was observed in this experiment. A high correlation between meal size and the duration of the interval after the meal (postmeal interval) has been observed in the rat (Davies, 1977; Le Magnen and Devos, 1980). A weaker correlation was observed between meal size and the duration of the interval before the meal (premeal interval). This relationship suggests that factors related to meal initiation are influenced by the size of the previous meal. Furthermore, factors that influence meal size are different from those involved in meal initiation. However, when log survivorship analysis is used to classify meals, no correlation between meal size and the duration of either the interval before or after it has been observed (Castonguay et al., 1986; Bigelow and Houpt, 1988; present experiment).

### Implications

Palatability, rather than novelty, may be responsible for greater consumption of diets containing spray-dried porcine plasma than of those containing dried skim milk. Caution should be used when extrapolating results of preference tests to situations in which only one diet is provided. Pigs preferred the spray-dried porcine plasma diet to the dried skim milk diet, and preference increased throughout 21 d. However, when not offered a choice between the two diets, pigs only consumed more of the spray-dried porcine plasma diet for approximately 7 d. The compound(s) in spray-dried porcine plasma responsible for increased palatability is(are) unknown.

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